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37. Proposed by F. P. MATZ, M. Sc., Ph. D., Professor of Mathematics and Astronomy in New Windsor College, New Windsor, Maryland.

I have three jars, A, B, and C, holding respectively $a=1$, $b=3$, and $c=5$ gallons. A is empty, B is full of water, and C is full of wine. I *fill* A from B; then I *fill* up B from C and pour the contents of A into C. After *repeating* this operation how much wine is there in B? How much in C?

I. Solution by Professor G. B. M. ZERR, A. M., Principal of High School, Staunton, Virginia.

After the first operation, B contains 1 gallon of wine, C contains 4 gallons. In the second operation $\frac{4}{5}$ gallons of wine are drawn from C and $\frac{1}{3}$ gallons added to C. C contains, $4-\frac{4}{5}+\frac{1}{3}=3\frac{8}{15}$ gallons of wine.
B contains, $5-3\frac{8}{15}=1\frac{7}{15}$ gallons of wine.

II. Solution by Professor T. W. PALMER, University of Alabama, I. L. BEVERAGE, Monterey, Virginia, and the PROPOSER.

After the *first* operation, A is empty, B contains $(b-a)$ gallons of water and a gallons of wine, and C contains $(c-a)$ gallons of wine and a gallons of water. In so far as changes in the proportional parts of the wine are effected by the *repetition*, A is empty, B has gained from C $[(c-a)\div c]$ of a gallons, and C has gained from B *through* A $(a\div b)$ of a gallons. Hence, after the repetition, the number of gallons of wine in B is

$$G_B=\left[1+\frac{c-a}{c}-\frac{a}{b}\right] \text{ of } a=\left[2-\left(\frac{1}{b}+\frac{1}{c}\right)a\right] \text{ of } a, =1\tfrac{7}{15}.$$

Consequently the number of gallons of wine in C is

$$G_C=c-G_B=c-\left[2-\left(\frac{1}{b}+\frac{1}{c}\right)a\right] \text{ of } a, =3\tfrac{8}{15}.$$

III. Solution by Professor J. F. W. SCHEFFER, Hagerstown, Maryland.

Let, after x such operations as described, the quantity of wine in the vessel B be $F(x)$, then $b-F(x)$ will be the quantity of water in B, $c-F(x)$ the quantity of wine in C and $F(x)$ the quantity of water in C.

Repeating the operation once more, we have in vessel B,

$$\frac{b-a}{b}F(x) \text{ wine } +\frac{b-a}{b}[b-F(x)] \text{ water}+\frac{a}{c}[c-F(x)] \text{ wine } +\frac{a}{c}F(x) \text{ water};$$

and in C, $\frac{c-a}{c}[c-F(x)]$ wine $+\frac{c-a}{c}F(x)$ water $+\frac{a}{b}F(x)$ wine $+\frac{b-F(x)}{b}$ water. $\therefore\ \frac{b-a}{b}F(x)+\frac{a}{c}[c-F(x)]=F(x+1)$ an equation in Finite Differences. Resolving, we find $F(x)=\frac{bc}{b+c}+C\left(\frac{bc-ab-ac}{bc}\right)^x$.

For $x=0$, $F(x)=0$. $\therefore\ C=-\frac{bc}{b+c}$; $\therefore\ F(x)=\frac{bc}{b+c}\left[1-\left(\frac{bc-ab-ac}{bc}\right)^x\right]$.

The quantity of wine in C is, of course, $=c-F(x)$.

For $x=2$, we have $F(x)=\frac{a(2bc-ab-ac)}{bc}$. For the numerical values we have $F(x)=\frac{15}{8}[1-(\frac{7}{15})^x]$ and $F(2)=1\frac{7}{15}$. The value to which $F(x)$ approximates is $\frac{bc}{b+c}$.

38. Proposed by J. A. CALDERHEAD, B. Sc., Superintendent of Schools, Limaville, Ohio.

What must be the thickness of a 36-inch shell, in order that it may weigh 1 ton; supposing a 13-inch shell to weigh 200 pounds, when two inches thick?

I. Solution by EDWARD R. ROBBINS, Princeton, New Jersey.

Given shell....Vol.$=\frac{734\pi}{3}$. Required shell of thickness $=x$....

Volume$=\frac{(4x^3-72x^2+1296x)\pi}{3}$. Now....$\frac{734\pi}{3}:\frac{4(x^3-18x^2+324x)\pi}{3}::1:10$ which gives....$x^3-18x^2+324x-1835=0$, whence $x=7.4817$ in. the required thickness.

II. Solution by G. B. M. ZERR, A. M., Principal of High School, Staunton, Virginia, and J. W. WATSON, Middle Creek, Ohio.

Volume 13-inch sphere $=\frac{1}{6}\pi 13^3=\frac{2197\pi}{6}$ cubic inches.

Volume of hollow$=\frac{1}{6}\pi 9^3=\frac{243\pi}{2}$ cubic inches.

Volume of 36-inche sphere$=\frac{1}{6}\pi 36^3=7776\pi$cubic inches.

Volume of hollow of 36-inch sphere$=\frac{1}{6}\pi D^3$ cubic inches.

$\frac{2197\pi}{6}-\frac{243\pi}{2}=\frac{734\pi}{3}$ cubic inches=volume of 13-inch shell.

$\therefore$ $\frac{734\pi}{3}$ cubic inches weigh 200 pounds.

$\therefore$ 1 cubic inch weighs$\frac{600}{734\pi}=\frac{300}{367\pi}$ pounds.

7776π cubic inches weigh $7776\pi\times\frac{300}{367\pi}=\frac{2332800}{367}$ pounds.

$\frac{1}{6}\pi D^3$ cubic inches weigh $\frac{1}{6}\pi D^3\times\frac{300}{367\pi}=\frac{50D^3}{367}$ pounds.

But$\frac{2332800}{367}-\frac{50D^3}{367}=2000$. $\therefore$ $D^3=31976$. $\therefore$ $D=31.74$ inches.

$\therefore$ $36-31.74=4.26$, $4.26\div 2=2.13$ inches.

$\therefore$ 2.13 inches is the thickness of the 36-inch shell.